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Abstract

Investigations of the Moderating Properties of Water

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A review is given of the work performed and going on in Sweden to investigate the moderating properties of water by various experimental and theoretical methods.

Using slow neutron time-of-flight spectrometers the nature of atomic motions in light and heavy water has been investigated, in the case of light water in the temperature range from -3 to +95°C and in the case of heavy water from -10° to +300°C. Generalized frequency distributions have been derived from the experimentally determined inelasticly scattered neutron spectra and found to exist even at +300°C. This fact as well as the width of the quasi-elastic peak indicates a clear solid-like behaviour of the water molecules. It is shown that the continuous diffusion model does not explain the width behaviour and that the gas model does not describe the translational motions of the water molecules. It is found that the quasi-elastic peak is to a high degree determined by the motion of the protons in the hydrogen bonds.

The time behaviour of neutrons during slowing down and thermalization in water has been studied by the use of a pulsed van de Graaff. Information on the change with time of the neutron spectrum was obtained from its reaction with spectrum indicators, the reaction rate being observed by the detection of capture gamma rays. Measurements were made with cadmium, gadolinium and samarium as indicators. A slowing-down time to 0.2 ev of 2.7 ± 0.4 μsec was obtained. From 9 μsec after the injection the results are well described by

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the assumption of the flux as a Maxwell distribution cooling down to the moderator temperature with a thermalization time constant of 4.1 ± 0.4 μsec.

The slowing-down time of Ra-Be neutrons in water to the cut-off energies of cadmium and gadolinium filters has been measured by a stationary method. The slowing-down time is derived from the ratio of the integrated neutron densities measured in a large medium using a 1/v-detector without and with the filter in question. The slowing-down times obtained are 1.60 ± 0.07 and 2.47 ± 0.11 μsec to the cut-off energies 0.5 and 0.3 ev respectively.

Various theoretical models for neutron slowing down in water have been compared with the integral experiments. A numerical solution of the Boltzmann equation for the proton gas model shows that the validity of this model is limited to energies above 0.4 ev. The Nelkin model is better, but the agreement with experiments is still not satisfactory. The possibilities of improvements based on the detailed differential measurement are discussed.